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## **BIOTECHNOLOGICAL RESEARCH IN UKRAINE FOR SOLVING ENERGY, MEDICAL-BIOLOGICAL AND MEDICAL-ECOLOGICAL PROBLEMS IN 2009-2015 TAKING INTO ACCOUNT THE IMPLEMENTATION OF THE ASSOCIATION AGREEMENT WITH THE EU**

### **Abstract**

This article summarizes the main results of the biotechnological research of the National Academy of Sciences of Ukraine aimed at solving energy, medical-biological and medical-ecological problems during the period from 2009 to 2015. The prospective bioresources and directions of implementation of the latest technologies of bioenergy conversion for the production of liquid biofuels and expansion of their use for biodiesel were determined. The latest medical and biological and bioengineering technologies for human health and the national economy, biologically active substances for human health, ecological and economic mechanisms of rational use, protection and monitoring of natural resources, new technologies for the efficient use of energy resources were presented in the article. The authors systematized the results of the current research of the National Academy of Science of Ukraine aimed at the development of modern methods for the prevention and diagnosis of diseases in humans and animals, modern methods of cell biotechnology and metabolic engineering for the creation of superproducts of biologically active substances, new forms of plants and microorganisms, the genetic design of improved microorganisms and lines of plant and animal cells for the development of medical and agricultural biotechnology. The authors proved that these directions of research fully correspond to the world-wide trends in research in biomedicine.

**Key words:** biotechnology, biofuels, medical and biological technologies, medical and environmental technologies, cell biotechnologies

### **1. Introduction**

Biotechnology is one of the priority areas among the wide range of innovative sectors of any developed national economy. Expansion of the practical significance of industry is driven by the social and economic needs of society. Such pressing problems that faced mankind at the beginning of the XXI century, such as a deficit of water and nutrients (especially proteins), environmental pollution, scarcity of raw materials and energy resources, the necessity to generate new environmentally-friendly materials and the development of new methods of diagnostics and therapies, cannot be solved by traditional methods. That is why biotechnological research with the aim of overcoming the energy problem (first of all through the creation and improvement of various biofuels) and the solving of medical, biological and environmental problems are of key importance in the present-day fight against global challenges. The scientific tasks of using biotechnology to solve global problems were studied by Sartakova, O. [1], McCormick, K., Kautto, N. [4], Kudriavtseva, O., Yakovlieva, K. [7], DaSilva, E.J. [8], Voynov, M., Volova, T., Zobova, N. [9], Matyushenko, I., Buntov, I., Moiseienko, Yu., Khaustova, V. etc. [10-18] and other Ukrainian and foreign researchers [2, 3, 5, 6].

### **2. Methodology**

Content analysis and bibliographic retrieval have been used as the main methods of research, which have enabled the making of a meaningful analysis of classic papers and the works of modern economists-

practitioners devoted to the Ukrainian trends in the scientific research of biotechnologies. General scientific methods make up the methodological foundation of the research. They include: description, comparison, statistics review, system analysis and others, which help to characterise the development of this phenomenon in a more comprehensive way. We also apply the methods of dialectic cognition, structural analysis and logic principles that allow the making of authentic conclusions as regards the investigated topic.

Official statistical data of the state institutions and international organizations, publications of reference character, analytical monographs, annual statistical bulletins, World and Ukrainian institutions and university reports serve as the information basis for our research.

### **3. Results and Discussion**

#### **3.1. The perspective of Ukraine's research into biofuel production and application**

The process of looking for new ways to use the energy resources of renewable energy accumulated by the living substance through photosynthesis, a biofuel, is of high importance nowadays. Soon, approximately 10% of total energy consumption may be covered by means of the products of photosynthesis. On the other hand, the modern Ukrainian energetics is significantly based on the import of energy commodities – oil and gas, and prices for these are constantly increasing [17].

The leader in solving this problem is Brazil: in this country, the annual production of bioethanol from sugar cane, for example, in 2006, exceeded 150 mln hl. The same amount of bioethanol was produced from maize in 2006 in the USA, but in 2012 the country raised production to about 284 mln hl. Simultaneously developing the manufacture of biodiesel fuel, i.e. biodiesel from rape and soya.

In Europe, the production of biodiesel mainly from rapeseed and soybean oil, and bioethanol from maize and other cereals is ramped up. This is due to certain directives that, on the one hand, contain regulations regarding the mandatory usage of additives to ethanol and biodiesel, while, on the other hand, create the economic conditions favouring the production of these energy sources. In the short term, it is thought that the biofuel share of total fuel consumption will amount to 10% with the further expansion of capacity. Different ways of biofuel generation are being examined. Ethanol generated from cereals is in first position, because average yields of maize, wheat and triticale exceed 80 dt per ha, the second position belongs to ethanol from sugar beet, and third position – to biodiesel from rapeseed. For instance, in France it is planned to triple biofuel production from its primary source in the years ahead and bring it up to 1 mln. 300 thousand tons in prospect. European countries differ in their priorities concerning biofuel production: France prefers maize, wheat, sugar beet; Germany is focused far more on biodiesel from rapeseed.

Sources for biofuel production such as agricultural, food, and forest waste (straw, maize stalks, stems and sunflower husks, sawdust, etc.) are beginning to be used today. Although they are not considered as a top priority, they could become quite an important source of raw materials in the future. Application of raw materials generated from specially modified fast-growing poplar varieties, and new species, particularly, miscanthus, as feedstock for biofuels is gaining in significance. Special emphasis on the use of fast-growing trees is being placed in China.

Taking into account soil and climate conditions in Ukraine, sources of biofuels can be placed in the following order: maize, triticale, wheat, different types of sorghum and millet, sugar beet, sunflower, rapeseed, agricultural and forest waste, miscanthus, poplar, sunflower husk and stalk. Of course, the leader of energy storage per hectare in the Ukrainian conditions is potato, but the problems of storing it until it is processed are not fully solved yet. In Ukraine it is not expedient to use agricultural waste as a feedstock for biofuel so far, because there is a growing deficit of organic matter in soils, and it is better to leave straw, maize stalks, maize and soya tops afield (except sunflower haulm). But in some cases with an excessive presence of waste, it can be processed into biofuels and chemicals.

In addition, until 2007, scientists of the National Academy of Sciences of Ukraine (NASU) already had a portfolio for the improvement and expansion of the raw materials base, the advancement of conventional technologies and the development of their own biofuels based on regional and technological particularities and the creation and enhancement of additives to commercial fuels. Meanwhile, the existing biofuel production in Ukraine is based on outdated and relatively expensive technologies that provide neither adequate costs, nor quantity [13, 18].

Taking into account the necessity of Ukraine to achieve energy self-sufficiency including a significant expansion of alternative fuel application, scientists from the Chemical and Biological sciences Section of the NASU prepared the Concept of the target comprehensive program for scientific research “Biomass as a fuel material” (“Biofuels”) - as provided by the Law of Ukraine “About alternative types of liquid and gas fuels” under the date of 14 January, 2000, № 1391-XIV (1391-14) and in the execution of cl. 4.2 of the NASU Presidium Resolution dated to 12 July, 2006, № 213 (v0213550-06).

According to the Resolution of the NASU Presidium dated 28 February, 2007, № 56, the NASU target comprehensive program for scientific research “Biomass as a fuel material” (“Biofuels”) was approved [19]. This concept indicates that up to 2007, NASU scientists had already performed the groundwork on the improvement and expansion of the raw materials base, advancement of traditional technologies and development of their own technologies on biofuel production based on regional and technological features, the creation and enhancement of additives to the commodity fuels, etc. However, current biofuel production in Ukraine is based on outdated and comparatively expensive technologies that provide neither realistic costs, nor quantity. Thus, the main purpose of the target comprehensive programme for scientific research “Biomass as a fuel material” (“Biofuels”) is to define the priorities in addressing the significant increase in various biofuel production efficiency by expanding the resource base, applying new non-traditional crops and improving the traditional ones by means of breeding and using genomics and biotechnology advances, creating and improving the technologies of biofuels and protein concentrate generation from different cultures and remnants of agricultural and forestry products.

The primary strategic priorities of the programme were: (1) identification of the most promising biofuel sources in Ukraine including non-traditional ones (poplar, willow, miscanthus and other new species); (2) development of production technologies and the main application areas of alternative bioenergy crops as a highly renewable source of energy. Providing consistently high yields of absolutely dry mass (10-20 tonnes per ha which is suitable for the generation of solid biofuels) and technical oil of high quality (900-1100 kg per ha as a source for biodiesel); (3) application of biotechnology and plant genetic engineering to increase production of biofuel raw materials from an area unit with minimal energy consumption and high content of nutrients, and also creation of plant-producers of oils; (4) improvement of technologies for biofuels (biodiesel and bioethanol) and protein concentrates generation out of vegetable feedstock with searching and genetic design of appropriate microbial strains; (5) development of methods for obtaining carbohydrates from dry waste biomass and searching for methods of ethylene generation from biomass (chemical and enzymatic processes); (6) biofeedstock application technologies for biofuel generation together with the creation of technologies for obtaining related organic chemicals (polilaktat, lactic acid, hydroxybutyric acid, glutamic acid, furfural and furfural-based products); (7) looking for ways to use the waste and by-products of biofuel production [19].

The most significant results of the programme mentioned above during the years 2007-2012 are included in Table. A.1 of Appendix A [20-24].

The NASU target comprehensive programme for scientific research “Biological resources and the newest bioconversion technologies” for 2013-2017 became a continuance of the research programme on Ukrainian biofuel generation. The concept of the programme was approved by the NASU Presidium instruction dated 20 March, 2013, № 189 [28; 29]. The most crucial results of the programme during 2013-2015 are included in Table. A.2 of Appendix A [25-27].

The mentioned comprehensive programme in case of its implementation will have the following results:

- Involvement of prospective biological resources, development and implementation of the newest bioconversion technologies for liquid biofuel production and expansion of their application;
- initiation of application of the most effective sources of raw materials including unconventional and alternative sources for biofuel production;
- generation of high-quality feedstock from energy-valuable plants including improvement of productivity indicators and alcohol and oil outcome;
- enhancement of quality and quantity content of energy-valuable substances (starch, sugar, oil, etc.) in biofeedstock for liquid biofuel production;
- creating new strains of microorganisms, fungi and algae, as well as expansion of their genetic resource base for the purpose of generation of liquid biofuels;

- improvement and development of the latest chemical technologies and application of new approaches to bioenergy conversion;
- development of the technologies of fatty acid chemical transformation into oils to produce biodiesel;
- improvement of existing and the development of alternative technologies for the generation of the fuel components necessary for biofuel production;
- utilization of agricultural, forestry, food processing and household waste as raw materials for biofuels;
- practical use of biofuel production by-products and waste;
- comparative analysis of different sources of bioenergy feedstock by taking into account their cost, environmental safety, and the possibility of obtaining additional useful products.

The reform and modernization of the energy sector in Ukraine is a challenge of the highest priority for both economic and geopolitical reasons. In the Agreement on the Association of Ukraine with the EU, two separate sections are devoted to energy issues: one section deals with trade issues, and the other concerns enhanced partnership in the field of energy policy. In both, reference is made to the Treaty establishing the Energy Community, which Ukraine joined as a full member in 2011 after the accession of Moldova in 2010. This Agreement provides for cooperation general terms, in essence, on the whole range of energy policy issues, including policy-making strategies, crisis management mechanisms, modernization of infrastructure, energy security, energy efficiency and energy conservation, as well as support for the development of renewable energy sources. Annex XXVII of the Agreement lists a large number of legislative acts of the EU and timetables for their "gradual adoption" by Ukraine. They cover the main provisions of the Treaty establishing the Energy Community, the deferral of which is not allowed. For other laws, the implementation period varies from two to eight years [37].

The Draft Energy Strategy of Ukraine, that was developed within the framework of the implementation of the Association Agreement, explains the energy intensity of the country's economy by a significant proportion of energy-intensive industries within the structure of GDP, the low energy efficiency of energy-transport sectors (for example, thermal energy generation, transportation and distribution of energy) and high energy consumption by households for heating and hot water. The average annual energy consumption in the residential sector is 250-270 kWh / m<sup>2</sup>, which is almost twice as high as in European countries with similar climatic conditions. According to the Energy Strategy, and in order to reduce energy intensity by 20%, Ukraine will reduce overall primary energy supply by 10% by 2020 (assuming GDP growth will resume from 2017). This should preferably be achieved by reducing gas consumption by 22%. By 2035, the share of renewable energy of the total primary energy supply is expected to reach 20% due to the replacement of coal and natural gas with biomass and bioenergy. It is anticipated that the energy intensity of GDP will fall to the level of 0.12 kg of conventional fuel for every \$ 1 of GDP.

In the years 2014-15, radical measures were taken in Ukraine to reform the energy sector, a factor which was a combination of the conditions established by the IMF with regard to providing macroeconomic financial assistance and legal obligations under the EU agreement and the Treaty establishing the Energy Community. As for renewable energy, Ukraine has a comprehensive framework for promoting renewable energy, but they are not yet fully aligned with the obligations under the Treaty. The government has abolished the discriminatory "local component", corrected the legal definition of "biomass" and introduced a number of incentives for the development of alternative heat supply and bioenergy in the country. At the same time, the regulator has reduced the "green" tariff, which led to the emergence of a certain number of lawsuits regarding the claims of investors.

### **3.2. The main research into the development of biotechnology in Ukraine for the solution of medical-biological and medical-ecological problems**

Studies aimed at solving medical and biological problems, as well as problems of interaction between the environment and human health were studied long ago and were presented by several comprehensive research programs at the National Academy of Sciences of Ukraine. For example, within the last 10 years since 2001, a complex scientific research programmer at the National Academy of Sciences of Ukraine "The latest medical and biological problems and the environment of a person" has been carried out and its implementation was completed in 2010 [30-32]. The aims of the implementation of the programmer were: (1) development of the latest medical, biological and bioengineering technologies for human health and the national economy; (2) biologically active substances for human health; (3) human environmental problems. The most significant

results of the implementation of scientific projects within the framework of this program for resolving global problems in 2007-2009 are given in Table B.1 of Appendix B [15, p. 448-452; 20-22].

During the continuation of these studies, the Resolution of the Presidium of the National Academy of Sciences of Ukraine dated 07.07.2010, № 222, launched the Target Complex Interdisciplinary Programme of Scientific Research of the National Academy of Sciences of Ukraine "the Fundamental Foundations of Molecular and Cell Biotechnology" for 2010-2014 [33]. Within the framework of the approved Concept of this programme, research was carried out into the areas of modern biology as: (1) a study of the features and mechanisms of the biomacromolecules, supramolecular complexes, subcellular and membrane structures functioning in health and pathology; (2) the development of the fundamentals of molecular and cell technologies for the diagnosis, prevention and treatment of diseases and the genetic improvement of living organisms; (3) the structural, functional and comparative genomics of humans, animals, plants and microorganisms; (4) the creation of biologically active preparations, new forms of plants and microorganisms. The most significant results of the 2010-2014 implementation of this programme for solving global problems are given in Table B.2 of Appendix B [15, p. 437-440; 23-26].

In 2015, the implementation of the new Target Complex Interdisciplinary Programme "Molecular and Cell Biotechnology for the needs of Medicine, Industry and Agriculture for 2015-2019" was launched. The main areas of research in this programme are: (1) studying the features of the transcript, proteome, immune, interactome and metabolome of humans in health and pathology for the needs of personalized medicine and the development of modern methods for the prevention and diagnosis of human and animal diseases; (2) the elaboration and development of modern methods of cellular biotechnology and metabolic engineering for the creation of support producers of biologically active substances, new forms of plants, microorganisms for the requirements of medicine and the national economy (particularly for cell and tissue engineering); (3) a target-oriented search for new or modified biologically active substances, the routes and means of their controlled delivery for the creation of the latest therapeutic agents; (4) molecular and genetic aspects of the study of the structural and functional organization of plants' and microorganism genomes as a fundamental component of molecular biotechnology; (5) a genetic basis for the construction of improved strains of microorganisms and lines of plant and animal cells for the development of medical and agricultural biotechnology [34]. The results of the implementation of the programme for solving global problems in 2015 are given in Table B.3 of Appendix B [15, p. 441-442; 27].

The research into medical and environmental problems has been actively carried out over the past ten years by the Division of Chemical and Biological Sciences at the National Academy of Sciences of Ukraine in cooperation with other departments of NASU and organizations of the Academy of Medical Sciences of Ukraine and the Ukrainian Agrarian Academy of Sciences, as a result certain progress has been made in solving interdisciplinary problems [10; 11].

An example of a state programme aimed at solving these problems is the Target Comprehensive Interdisciplinary Scientific Research Programme of the National Academy of Sciences of Ukraine on the problems of sustainable development, the rational use of natural resources and the preservation of the environment for 2010-2014, approved by the Presidium of the NAS of Ukraine dated February 3, 2010 № 31 [35; 36]. The results of the implementation of this programme are: (1) the development and submission to the authorities of the draft Concept and Strategy of the Sustainable Development of Ukraine and the relevant National Action Plan; (2) the development of effective ecological and economic mechanisms of the rational use, protection and monitoring of natural resources; (3) the development of new technologies for the efficient use of energy resources; (4) further development of new and effective functioning of existing facilities of the natural reserve fund, including biosphere reserves.

The Section of the EU-Ukraine Association Agreement on Environmental Protection is extremely ambitious and obliges Ukraine to cooperate on a wide range of issues related to state environmental policy. Ukraine has agreed to gradually synchronise its legislation to EU legislation in the two to ten years period, in accordance with Annex XXIX of the Agreement, which lists the 35 EU directives. They represent the bulk of EU nature conservation legislation and policies, including environmental management practices, air and water quality, waste management, industrial pollution and hazard, nature protection, the use of GMOs (genetically modified organisms) in agriculture and climate change.

In 2015, the Cabinet of Ministers of Ukraine approved 21 Plans for the implementation of 26 environmental directives and regulations of the EU, which define the measures for ministries and departments for timely implementation of EU environmental legislation. These plans are essential for ensuring transparency and effective monitoring of civil society and business representatives' implementation. Thus, administrative planning has advanced fairly, which is the first step of a long process [37].

The Directive on Environmental Impact Assessment Over the past few years, several bills have been registered in Parliament with a view to implementing this directive, but none of them has been agreed for several reasons, mainly because of the resistance of business lobbyists and civil servants who are interested in maintaining the status quo.

The Directive on industrial emissions. Despite the fact that the national legislation of Ukraine partly complies with the requirements of this Directive (2010/75 / EC), much work has to be done to develop the required by-laws and regulations, which are partly covered by technical assistance projects. According to the implementation plan, which was approved by the Cabinet of Ministers in 2016, most of these measures should be implemented during the years 2015-2017.

The Framework Directive on atmospheric air quality. The national legislation of Ukraine is currently partly in line with the provisions of the Air Quality Directive (2008/50 / EC). Nevertheless, the air quality monitoring system needs some improvement, since it was launched more than 20 years ago. The main legislative and institutional measures identified in the Implementation Plan must be completed by 2017. Nevertheless, the technical re-equipping of existing air quality monitoring stations and the development of air quality improvement plans are scheduled for 2016-2019 through the implementation of technical assistance projects.

The Framework Directive on Water Resources. In accordance with the Transposition Plan of the Water Framework Directive (2000/60 / EC), the national legislation of Ukraine should be completed by 2017. Important steps have already been taken with the creation of an interdepartmental working group by the State Agency for Water Resources in 2015. The draft law introducing changes to the text on integrated approaches to water management issues was registered by the Parliament on December 9, 2015, and was approved at the first reading on May 19, 2016.

#### **4. Conclusions**

The authors found that implementation of biotechnology in Ukraine results from the urgent need to solve the energy problems and the related medical, biological and environmental problems. The intensive development of biotechnological research is due to the need to increase the competitiveness of domestic commodity producers in the external and internal markets under conditions of deep integration of Ukraine with European countries and implementation of the Association Agreement between Ukraine and the EU.

The authors also found that during the implementation of the integrated programmes "Biomass as a fuel material" ("Biofuels") and "Biological resources and the newest bioconversion technologies" in 2007-2015, scientific institutions of the National Academy of Sciences of Ukraine in order to expand the use of alternative fuels by the use of biofuel continued to work on the involvement of prospective bio-resources, the development and implementation of the latest bioconversion technologies for the production of liquid biofuels and the expansion of their use, improvement and development of the latest chemical technologies for the production of biodiesel, utilization of agricultural, forestry, food processing and household waste as raw materials for bio-fuels.

As for renewable energy, Ukraine has a comprehensive framework for promoting renewable energy, but they are not yet fully aligned with the obligations under the Treaty. The government has abolished the discriminatory "local component", corrected the legal definition of "biomass" and introduced a number of incentives for the development of an alternative heat supply and bioenergy in the country. At the same time, the regulator reduced the "green" tariff, which led to the emergence of a certain number of lawsuits on the claims of investors.

The authors demonstrated that during the implementation of the interdisciplinary programmes of the National Academy of Sciences "Recent medical and biological problems and the human environment" and "Programmes

on sustainable development, the rational use of nature and environmental preservation" in 2001-2014, the latest medical, biological and bioengineering technologies for human health and the national economy, biologically active substances for human health, ecological and economic mechanisms of rational use, protection and monitoring of natural resources and new energy-efficient technologies for energy resources were developed.

It was established that during the years 2008-2015 in Ukraine, within the framework of the interdisciplinary programmes of the NASU "Fundamental Foundations of Molecular and Cell Biotechnology" and "Molecular and Cell Biotechnology for the needs of Medicine, Industry and Agriculture", the main research was focused on the development of modern methods of human and animal disease prevention and diagnoses, modern methods of cellular biotechnology and metabolic engineering for the creation of the superproducts of biologically active substances, new plant forms and microorganisms, genetic design of improved microorganism strains and lines of plant and animal cells for the development of medical and agricultural biotechnologies. The indicated directions of research completely correspond to global trends into research in biomedicine.

In 2015, the Cabinet of Ministers of Ukraine approved 21 Plans for the implementation of 26 environmental directives and regulations of the EU, which define measures for ministries and departments for timely implementation of the EU environmental legislation. Thus, administrative planning has advanced fairly, which is the first step of a long process.

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**Appendix A**

Table A.1. The most significant results of the NASU target comprehensive programme for scientific research “Biomass as a fuel material” (“Biofuels”) during 2007-2012

Year	Sector of the programme	The most significant result	Practical utility	
1	2	3	4	
2007	Sources of biofuel generation and increase in feedstock efficiency	High-yielding varieties of sorghum, sorice (rice and sorghum hybrid), korakan, artichoke, sunflower artichoke with estimated ethanol outcome from 150-200 dal/ha to 450-900 dal/ha were defined	Genetic pool of plants with high oilness and lipid outcome was made up	
		The screening of cellulolytic activity of a wide range of microorganisms strains was conducted, the most prospective ethanol strains-producers were selected	Prospective strains-producers of ethanol were selected	
	Chemical technologies of biofuels and the generation their by-products	Polymeric membranes that can operate at a temperature of up to 6000C and pressure to 10,0 MPa are manufactured and studied	Polymeric membranes that can operate at high temperature and pressure	
		New nanoporous carbon material with uniquely high marginal adsorption capacity as to absorbing benzol pair and reactive isocyanate-acrylate oligomers out of vegetable oils were derived	New materials for generating polymeric materials	
		A number of biodiesel samples were synthesized, basic operation parameters for them and a range of new surface-active agents were defined	New samples of biofuels and new substances that are additives to grease	
		Parameters of cheap coal-containing high-porous adsorbents out of synthetic resins and fruit pits were optimized, their prototypes were studied	Creation of heterogeneous catalysts for biodiesel synthesis	
	Technologies of biofuel production and application	Technical requirements and design documentation on a research plant to produce liquid biofuels and homogenizer-heat-generator were developed; a laboratory-scale plant scheme for biogas outcome and content estimation with co-digestion of various substrates was designed, basic elements of technology and equipment for biogas transport and fundamental construction of vortex burner for simultaneous and separate combustion of biogas and natural gas were developed; technological schemes of electric and thermal power production by gas reciprocating engines on the biogas basis were created	Documentation on a research plant to produce liquid biofuels; elements of laboratory equipment for production, transportation and combustion of biogas; schemes of electric and thermal power production on the biogas basis	
		Prototrophic meiotic segregants with higher thermotolerance were generated; they produce 15-20% of ethanol more than output strains and industrial yeasts do	New more productive strains of industrial yeasts	
	2008	Sources of biofuel generation and increase in feedstock efficiency	13 crop varieties were obtained and their expert examination as bioethanol sources was made	Looking for new varieties-sources of bioethanol
			Highly stress-resistant varieties of non-traditional crops as to Ukraine for biodiesel production, three of them are registered in the State Commission on crop variety testing	Three new crop varieties for biodiesel production
8 transgenic plants of potato of “Lugivska” variety and 39 lines of high productivity rape were obtained			Plants of high productivity	
Chemical technologies of biofuels and their by-products generation		Microbial strains that are active digestion tanks of carbohydrates (mono- and disaccharides including cellobiose) were discovered among yeast fungi of the Ukrainian collection of microorganisms; yeast promoters induced by ethanol were selected.	Recombinant constructions and strains for application within positive selection of yeast overproducers	
	A range of additives of anti-friction purpose for oil lubricants production was synthesized	Rape-oil-based lubricants		

Year	Sector of the programme	The most significant result	Practical utility
		Factors that influence structuring active catalyst centres of biofuel synthesis on the basis of smectite-like laminated metasilicates, double mixed oxides, zeolites, and mesostructured silica	Biofuel synthesis
	Technologies of biofuels production and application	A pilot plant for biodiesel production on a continuous basis by means of ethanol reesterification of rape oil on heterogeneous acid and base catalysts was constructed	Pilot plant for biodiesel production
		Rheological characteristics of a range of fuel blends were determined	Characteristics of fuel blends
		Research into co-combustion in sawdust stream with pulverous anthracite of increased ash content (24-28%) as a natural gas substitute in a steam-generator furnace was conducted	Natural gas substitute in a steam-generating unit
		Two variants of experimental furnace devices for continuous combustion of full straw bales were developed and constructed	Firebox devices for straw bales burning
		Legal and financial tools for stimulation of bioenergy development in the EU and the US were analyzed, the expediency of their implementation in Ukraine was considered. It was defined that the best prospects of biofuel production in Ukraine could be based on lignocellulosic feedstock and technologies of the 2 <sup>nd</sup> generation	Defining the best prospects for biofuel production in Ukraine
2009	Sources of biofuels generation and an increase in feedstock efficiency	One of the biggest Ukrainian collections of power plants was created, it includes 352 taxones (139 oil-bearing, 71 – sugar crops, and 142 – commodity crops for biofuel and biogas production)	Collection of power plants
		A collection of microalgae strains – prospective lipid producers was formed, their molecular and genetic analysis was conducted	Collection of microalgae strains – lipid producers
	Chemical technologies of biofuels and the generation of by-products	The “cytokininoxidase” gen of korakan was identified, it is responsible for higher biomass growth; mutant maize hybrids on the waxy gen basis with changed starch content in seeds for bioethanol production were generated	Genetically modified mutant maize hybrids with a high starch concentration
	Technologies of biofuel production and application	Pilot plant module for biodiesel generation on the solid catalyst basis in periodic and continuous modes was designed and tested	Pilot plant module for biodiesel generation
		Methods of generation of catalyst mixtures nanoclusters inside nanopores of activated anthracite were optimized and recommended for biomass gasification in high-performance membrane reactor	Best practices for biomass gasification
		Biogasoline formulation was developed; a research party of biogasoline E 10, E 80 and E 85 was created on the basis of commodity straight run gasoline, motor petrol A-76, bioethanol and technological agents complying with the State Standards of Ukraine and ISO	Formulation and manufacturing of experimental biogasoline party
		Original diesel fuel was tried with the use of a tractor diesel engine; the fuel was synthesized using the technology of ethanol reesterification of rape oil, in mixtures with traditional diesel fuel, its energy and ecological advantages in comparison to oil diesel fuel of premium quality (Euro) were identified	Original diesel oil synthesized from rape oil and mixed with traditional diesel oil

Year	Sector of the programme	The most significant result	Practical utility
		Technological scheme of the biodiesel production enterprises a with capacity of between 8 and 128 thousand tonnes per year	Scheme of the biodiesel production enterprises
		Tyre rubber modifiers on the basis of vegetable oil hydrazides were created	Increasing dynamic parameters of tyre rubber
2010	Sources of biofuel generation and an increase in feedstock efficiency	Overview of introduction resources of non-traditional spring and winter crops with a high oil content was conducted	Overview of non-traditional crops with a high oil content
		The most favourable varieties and forms of miscanthus and switch grass for bioethanol production were selected; their genetic pool was created	The most favourable plants for bioethanol production
	Chemical technologies of biofuels and the generation of by-products	Fermentation and the butanol generating process by means of oleic acid that significantly increased yield, volume productivity and the concentration of butanol were optimized	Increase in outcome, volume productivity and the concentration of butanol
		The technology of homogenous-catalytic ethanol reesterification of rape oil for reducing glycerine content and mono- and diglycerides in the mixture of ethyl esters of fatty acids (biodiesel fuel) was improved. The produced fuel overcomes the parameters of petroleum-derived diesel fuel and does not need special adaptation of the diesel engine's fuel system	The obtained diesel fuel can be used on working diesel equipment in a wide range of combinations with petrodiesel
	Technologies of biofuel production and application	Research into the regime of production of liquid motor and power fuels with vegetable-based bio-components was conducted. Samples of biofuel mixtures of traditional motor and power fuels (diesel fuel, residual fuel oil) with bio-components (vegetable oils, biodiesel, bioethanol) were produced.	Biofuel mixtures of traditional motor and power fuels with bio-components
		A laboratory plant of fast pyrolysis for liquid fuel production from biomass was constructed, adjusted and launched	Plant for liquid fuel production from biomass
2011	Sources of biofuel generation and an increase in feedstock efficiency	New varieties of miscanthus and switch grass as sources of bioethanol were created	New crops varieties as a source of bioethanol
		As a result of microalgae molecular and genetic analysis, 7 of the most favourable microalgae strain-producers of biomass were defined	Prospective microalgae strain-producers of biomass
	Chemical technologies of biofuels and the generation of by-products	It was defined that oligomers on the basis of epoxidized oil and trichloroacetic acid are self-extinguishing and can be used for the development of self-extinguishing coatings and sealing compositions	Substances for the development of self-extinguishing coatings and sealing compositions
		Improved technology for biodiesel fuel generation on the basis of renewable raw materials base was proposed and the research plant was adapted	Technology and equipment for biodiesel fuel generation
		Technical specifications and provisional technological regulations for the application of <i>Phospholidin</i> agent (one of the best polyfunctional additives to lubricating materials) were developed	Technology of the application of <i>Phospholidin</i> agent to lubricating materials
		Thermophysical properties of processing under liquid biofuel mixture production based on diesel fuel, petrol, vegetable	Properties of biofuel mixture production

Year	Sector of the programme	The most significant result	Practical utility
		oils, biodiesel, and ethanol	
	Technologies of biofuel production and application	A laboratory plant with a hydrodynamic cavitator for benzoethanol production was constructed. According to estimates, savings of the benzoethanol application for vehicles with spark ignition and electronic control could be 15-40% of operating costs	Plant for benzoethanol production
		The formulation of motor biofuel E 85 was optimized, its research party was made, motor tests were conducted	Research party of motor biofuel E 85
		Effectiveness of co-digestion of humus and ensilage in terms of periodic standing process at a temperature of $35 \pm 10C$ was studied. Biogas outcome and its content under the conditions of digestion of test mixtures with different proportion of organic matter were defined	Technology of biogas generation within co-digestion of humus and ensilage
		The model of biogas extraction with an individual hole and a group of holes was improved, a system of biogas collection taking into account the physical conditions of one of the Ukrainian field test sites was developed	System of biogas collection taking into account the real physical conditions of a field test site
		A mobile test installation was created and experimental research on the limited system of biogas collection was conducted	Research on the limited system of biogas collection
2012	Sources of biofuel generation and an increase in feedstock efficiency	Suitable crops for biodiesel manufacturing and the technology for their cultivation over an area of about 3,000 ha, miscanthus and switch grass varieties for biofuel production in Ukraine positioned on an area of about 180 ha were implemented	Implementation of suitable crops for biodiesel manufacturing
	Chemical technologies of biofuels and the generation of by-products	Method of generation of <i>Desmodesmus</i> microalgae biomass	Method of microalgae biomass generation
		Recombinant <i>Saccharomyces cerevisiae</i> yeast strains characterized by enhancement of the efficiency of alcohol fermentation were created	New recombinant yeast strains
	Technologies of biofuel production and application	A construction was developed and a laboratory plant for the co-digestion of firm food waste with biofuel generation was arranged. Technological plant of biodiesel fuel generation by homogeneous-catalytic reesterification of oil by ethanol was constructed and approximately 900 kg of the product were produced. The synthesized products have not only ecological indicators, but also energy ones in contrast with the diesel fuel made in Ukraine according to the current State Standard of Ukraine #3868-99	Plants for co-digestion of firm food waste and for homogeneous-catalytic reesterification of oil by ethanol with biofuel generation
		The construction documentation for scientific and technical work "Status of biofuel mixture preparation" with productivity of 1000 kg/hour was created. Construction documentation for a new disk-cylindrical disperser-homogeniser was developed, it is the main working node of the developed plant. The opportunity for launching the scientific and technical work into serial production was provided	Status of biofuel mixture cooking was implemented at "Il-Prom" Ltd. and PJSC Research and Production Enterprise "Bolshevik"
	The first Ukrainian plant for fast pyrolysis of biomass was constructed and pyro-fuel (bio-oil) samples were generated. Recommendations for the engineering of an ablative	Plant for fast pyrolysis of biomass was constructed at the state enterprise	

Year	Sector of the programme	The most significant result	Practical utility
		biomass pyrolysis pilot facility were developed	“GreenEnegro”
		Formulation of the biofuel E 85 was optimized, its research part was made, and its motor tests were conducted. It was defined that within engine operation on the basis of E 85, fuel toxicity of used gases significantly comes down in comparison to gasoline. Also it was found that engine efficiency at all the operating modes working on bioethanol motor fuel E 85 is higher than on gasoline	New biofuel E 85 that reduces the toxicity of used gases and increases engine efficiency at all the operating modes

Composed by: [20-24].

Table A.2. The most significant results of the NASU target comprehensive program for scientific research “Biological resources and the newest bioconversion technologies” for 2013-2017 during 2013-2015

Year	Sector of the programme	The most significant result	Practical utility
1	2	3	4
2013	Biological resources and the technological basis for their primary processing	Screening of 87 strains of green algae, potential biodiesel producers, was carried out. Suitability of butanol producers within alternative substrates application was defined, the most effective strain-producer of butanol, <i>C.acetobutylicum</i> IFBG C6H, was deposited	The most effective strain-producer of butanol was defined
	Chemical aspects of the newest bioenergy-conversion technologies	Energy- and resource-saving method of two-stage transformation of triglycerides by means of ethanolysis with the following sulphidizing of higher fatty acid ethyl esters was created. It allows a decrease in the temperature and duration of the process, excludes emissions of hydrogen sulphide and the use of methanol. The synthesized products are toxicological and ecological safe	Designed materials increase friction characteristics and protection properties of lubricants as to ferrous and non-ferrous metals without using corrosion inhibitors
		An effective and stable catalyser (Cu/Al <sub>2</sub> O <sub>3</sub> -Cr <sub>2</sub> O <sub>3</sub> ) for hydrogenation of ethanol-glycerine mixture into propylene glycol was developed. The opportunity of the selective obtaining of glycerine 2,2,4-trimethyl 1,3-dioxane according to the front-side split conversion scheme is demonstrated	Generation of the high-octane component of gasoline
		It was found with the help of bed tests of ethyl flax-seed oil acids esters on a commercial tractor engine that mixtured fuels (20-60% volume esters) overcome petroleum-derived diesel fuel in terms of exhaust gases and combustion efficiency according to adopted energy-efficient indicators of engine operation	High efficiency fuel mixtures with the use of esters of flax-seed oil acids
	Technical basis for the newest bioenergy-conversion technologies	A pilot facility for liquid pyro-fuel generation by biomass pyrolysis was designed and manufactured. The first series of experiments on fast pyrolysis of crushed wood biomass (sawdust) with bio-oil generation was conducted. The created facility has a productivity of up to 4,65 kg/hour as to feedstock processing with bio-oil output up to 51,3% of the processed biomass weight	Equipment for liquid pyro-fuel (bio-oil) generation

Continued Table A.2

1	2	3	4
		With the help of an advanced and verified thermophysical model, the parameters of biogas generation, filtration, and collection were calculated. A schematic design of the low cost reconstruction of Bortnitska aeration station was developed for the purpose of simultaneous biogas and natural gas burning and enlargement of biogas income to a boiler-house owing to reduction of losses in methane-tanks and gas-bags	Reconstructi-on of the existing aeration plant with simultaneous burning of biogas and natural gas
2014	Biological resources and the technological basis for their primary processing	New genotypes of winter and spring cabbage crops (typhon, rocket cress, camelina, mustard) were created	Genotypes of cabbage crops
		A research short-rotary plantation of fast-growing poplars was developed and prospective varieties for short-rotary plantations were identified	Prospective plants for short-rotary plantations
		New varieties of power plants (forage sorghum, perennial sorghum, switch grass, camelina sativa, winter rocket cress, typhon) and the technologies of their cultivation and application in various fields were implemented in Ukraine	New varieties of power plants
	Chemical aspects of the latest bioenergy-conversion technologies	Laboratory plant equipped with the node of a sharp decrease of operation pressure to the atmospheric one was made; it allows the study of the process of explosive autohydrolysis of vegetable biomass at a wide range of temperatures and pressures.	Research on the process of explosive autohydrolysis of vegetable biomass
		The influence of benzoethanol content on the operational characteristics of a transport engine was discovered. The method of adaptation of an engine to benzoethanol was developed	The most effective engine operation on the base of different mixtures
		It was found with the help of bed tests of ethyl esters of maize oil acids that mixtures of fuels (20-60% volume esters) overcome petroleum-derived diesel fuel in terms of exhaust gas content (content of CO, CO <sub>2</sub> , NOX, CH, smokiness) and combustion efficiency	New mixtures of fuel on the basis of maize oil
	Technical basis for the latest bioenergy-conversion technologies	A pilot facility was modernized and a series of tests on the research of fast pyrolysis of sawdust were carried out. The process of pyro-fuel generation from sawdust by ablative pyrolysis in a reactor with a cone-shaped screw was worked out	Process of pyro-fuel generation from sawdust
A stand for research on biogas and natural gas burning was developed and constructed, the influence of conditions of biogas and natural gas ray mutual bracing was defined. Elements of swirl and hearth burners of simultaneous biogas and natural gas burning for typical boilers were developed		Burners of simultaneous biogas and natural gas burning	
2015	Biological resources and technological basis for their primary processing	New varieties with high oil content and hybrids with improved draught, cold and frost resistance, and high crop yield of above-ground mass were created for enhancement of the outcome indicators of biodiesel oil feedstock. Cluster analysis of SSR-locuses of Camelina was conducted, methodical approaches to application of them as molecular-genetic markers for further selection were developed	New varieties with high oil content and hybrids with improved properties

Continued Table A.2

1	2	3	4
2015	Chemical aspects of the latest bioenergy-conversion technologies	Ethyl esters of mustard oil were synthesized with the use of a main homogenous catalyzer, bed tests of the mixtures with oil diesel fuel based on a diesel tractor engine were conducted	New mixtures of biodiesel and petrodiesel
	Chemical aspects of the latest bioenergy-conversion technologies Technical basis for the latest bioenergy-conversion technologies	Optimum temperature and pressure for explosive autohydrolysis of vegetable biomass (maize cobs, switch grass, drooping birch bark, low- and highland peat) were selected in vitro	Optimum temperature and pressure conditions for explosive autohydrolysis of vegetable biomass
		Technologies of the production of composition granulated peat fuel were developed, allowing an increase in calorific capacity of granulas to 25%, density – to 22%, and a decrease of energy consumption of granulation. Modes of heat processing and composition content of peat and biomass mixture were developed for peat fuel generation with a calorific value of 4800-5000 kcal/kg. A process of pyro-fuel generation out of sawdust by ablative pyrolysis in a reactor with a cone-shaped screw was worked out	Technologies of production of composition granulated peat fuel of higher calorific capacity and density
Technical basis for the latest bioenergy-conversion technologies	Technical basis for the latest bioenergy-conversion technologies	An automated machine for current definition of benzoethanol content was constructed, allowing an increase in the efficiency of biofuel application in automobile transport, broadening a range of bio-oil mixtures for motor power and reducing the rate of polluting emissions through used gases	Increasing efficiency of biofuel application in automobile transport and a decrease in the rate polluting emissions
		Technical projects on installing two hearth burners to the boiler of Bortnitska aeration station were developed, a working project of the existing burners' reconstruction was implemented	Installation of new burners and reconstruction of existing ones

Composed by: [25-27].

**Appendix B**

Table B.1. The most significant results of the implementation of the NASU comprehensive program for scientific research "Recent medical and biological problems and the human environment" during 2007-2009

Year	Sector of the programme	The most significant result	Practical utility	Branch	The global problem
1	2	3	4	5	6
2007	The latest biomedical and bioengineering technologies	The features of changes in the activity of different classes of calcium channels in the primary nociceptive neurons in pain syndromes were determined by the experimental models of the nervous pathology	Features of changes in the activity of calcium channels in pain syndromes	Medicine	Depopulation and the ageing of the population
		The high potential of methylphosphonate derivatives of the 2,814,20 tetraacalix[4]arene as an effective inhibitor of metal-dependent alkaline phosphatase was demonstrated for the first time	Inhibitors of metal-dependent alkaline phosphatase	-«-	-«-



Year	Sector of the programme	The most significant result	Practical utility	Branch	The global problem
		A new diasoxide analog was synthesized and tested	Treatment of cardiovascular diseases	-«-	-«-
		Immunoglobulin against toxoplasma was created and its activity is 1700 international units, that does not change over a period of 6 months	Sustained high-level immunoglobulin against toxoplasma	-«-	-«-
	Biologically active substances	A number of varieties of wheat were identified and they are resistant to the action of the local populations of brown rust, powdery mildew and septoriosis	Disease-resistant varieties of wheat	Agriculture	Food shortage
	Human environment	Floating carriers for the manufacturing of photocatalysed sorbents with pre-set floatation were created	Purification of natural reservoirs and sewage	Environmental protection	Pollution of the environment
2008	The latest biomedical and bioengineering technologies	Clinical studies of the cardioprotective effect of Epatol preparation in patients with coronary heart disease and detection of an improvement in their condition during the second week of medication administration	Cardioprotective effects of Epatol	Medicine	Depopulation and ageing of population
		A method of synthesis of new segmented polyurethanes that do not cause aortic inflammation was developed	Cardiovascular surgery	-«-	-«-
2008	The latest biomedical and bioengineering technologies	A significant increase in the expression of Ruk/CIN85 in the papillary cancers of the human thyroid gland was revealed.	Makes it possible to consider this adaptor protein one of the markers of tumor growth	-«-	-«-
		The State Pharmacological Center of the Ukrainian Ministry of Health approved the analytical and normative documentation for a substance based on 5-aminolevulinic acid hydrochloride	Photodynamic cleaning of bone marrow autotransplants from leukemic cells	-«-	-«-
		The medication "Diazocid" was obtained and patented, which shows a hypotensive effect without the onset of arrhythmia	Hypotension medication	-«-	-«-
		Composite sorbents of various composition based on the peloid were synthesized and a series of absorption of heavy metals was obtained for them	Composite sorbents	-«-	-«-
		The technology of synthesis of semi-products for separate derivatives of in-dolohinoxaline and naphthalamide has been developed to study them as inducers of interferon and antiviral agents.	Inductors for interferon and antiviral agents	-«-	-«-
		The pre-clinical study of the medication "Metovitan" was completed, the technology of production was transferred to the chemical and pharmaceutical company CJSC "Technolog" (Uman)	Production technology of the medication "Metovitan"	-«-	-«-

Year	Sector of the programme	The most significant result	Practical utility	Branch	The global problem
		A patent for nanobiotechnology for obtaining a bactericidal composition containing marine biopolymers and ultrasound particles of silver was obtained	Nanobiotechnology for the production of bactericidal composition	-«-	-«-
		A test-evaluation of the level of immunodepression in oncological diseases with the use of native interleukin 12 was developed.	Test-evaluation of the level of immuno/depression in oncology	-«-	-«-
		The technology of production of the ointment Teobon-dithiomycocide was developed and patented	Ointment Teobon-dithiomycocide	-«-	-«-
		Methods for the synthesis of oligoetherbisalicylates and oligoethers that bind uranium and transuranium elements were proposed	Substances that bind these types of elements	-«-	-«-
		It was demonstrated that a pharmaceutically valuable human $\alpha 2b$ interferon can coexist in <i>N. excelsior</i> plants in the context of transient expression	Accumulation of human interferon in plants	-«-	-«-
		The regularities and mechanism of macrocyclic inhibitors' effect of calix[4]arene and tcaliks[4]arene-tylphosphonic acids on the activity of Zn-dependent alkaline phosphatase from shrimp and other sources were investigated	Properties of macrocyclic inhibitors	-«-	-«-
		The effectiveness of antioxidant and antiradical action of a number of medicinal plants extracts under UV irradiation was investigated	Antioxidant and antiradical effects of medicinal plants	-«-	-«-
	Biologically active substances	As a result of selection tests, high protein wheat (up to 17,4% protein in grain) were selected, and they can serve as the source material for the creation of high-quality starins	High-protein wheat lines as a source material for new strains	Agriculture	Food shortage
	The Human environment	An original construction of the electro dialysis concentrator-separator for deep concentration of saline solutions was constructed	Provides efficient treatment of the concentrates of wastewater salts	Environmental protection	Pollution of the environment
		Composite materials based on natural zeolites with high bactericidal and fungicidal activity were suggested	Composite materials with bactericidal and fungicidal characteristics	-«-	-«-
		The efficiency of the purification of rivers and soils from oil contamination with new preparations "Kelan" and "Rod oil", which were created on the basis of active strains of hydrocarbon destroyers, was investigated.	Preparations for the purification of river water, soils	-«-	-«-
2009	The latest biomedical and bioengineering	Genetic constructions were created and they make it possible to express recombinant proteins (TB, human somatotropin hormone, interferon) and separate them from all other components of the herbal extract	Ability to purify protein in one stage	Medicine	Depopulation and ageing of population

Year	Sector of the programme	The most significant result	Practical utility	Branch	The global problem
	technologies	For the first time, a visionary sorption matrix for the creation of application composites within immobilized biologically- active complex of Nano silver with an alginate lining based on an activated carbon fibrous sorbent in the form of a material possessing powerful bactericidal properties was developed	Technical specifications for "Silver Carbon Tie Bonding" and "Fibrous Carbon Materials for Bandaging" were developed	-«-	-«-
		A new fluorine-containing analogue of Diazoxid, which acts on heart performance, vascular tone and hemodynamic parameters, was developed.	Low-toxic medicinal product	-«-	-«-
		The semi-industrial technology for obtaining the finished form of "Calmed" and "Calmed M" preparations for the treatment of bone marrow diseases with high specific activity in the normalization of vitamin D, mineral, lipid metabolism and structural and functional activity of bone tissue in alimentary osteoporosis was developed and designed.	The technology of obtaining the finished form of the drugs "Calmed" and "Calmed M" for the treatment of bone tissue diseases	-«-	-«-
		The standard specific immunoglobulin against toxoplasma and specific immunoglobulin against the anti-viral worm virus were developed and tested, and the stability parameters of the standard specific immunoglobulins were identified	Standard specific immunoglobulins against toxoplasma and tertiary sclerosis virus	-«-	-«-
	Biologically - active substances	For the first time, the effectiveness of a biologically active lipid N-stearoylethanolamine (NSE) as an antitumor agent that is capable of inhibiting the growth of the primary tumor individually was proved	Biologically active lipid, which inhibits tumor growth	-«-	-«-
	Human environment	It was found that a stay at a height of 2100 m (Elbrus area) is accompanied by positive changes in the lipid plasma spectrum of blood, a decrease in glucose content, a tendency to normalize metabolic shifts and a decrease in pathological manifestations of volunteers	A beneficial effect on the human body from staying at a height above sea-level of over 2000 meters	-«-	-«-

Composed by: [20-22].

Table B.2. The most significant results of the Target Complex Interdisciplinary Programme "Fundamental Foundations of Molecular and Cell Biotechnology" for 2010-2014.

Year	Sector of the programme	The most significant result	Practical utility	Branch	The global problem
1	2	3	4	5	6
2011	Features of biomacromolecules complexes	The search for inhibitors which will become the basis for the creation of new antibacterial drugs with selective action against pathogenic bacteria were carried out	Antibacterial drugs against tuberculosis and enterococcal infections of a	Medicine	Depopulation and ageing of population

Year	Sector of the programme	The most significant result	Practical utility	Branch	The global problem	
			person			
	Molecular and cellular technologies	Prototypes of test systems for DNA-diagnostics of the most common monogeneous hereditary diseases in Ukraine and the genetic factors of hereditary predisposition to stroke development were created	DNA-diagnostics of hereditary diseases	-«-	-«-	
	Genomics	Vectors containing the genes of herbicide resistance were constructed	Receiving of herbicide-resistant plants	Agriculture	Food shortage	
	Biologically active substances	The laboratory technology for the production of biologically active substances rich in biogenic stimulants from marine raw materials was developed	Biologically active supplements for nutrition and as components of medical preparations	Agriculture Medicine	Food shortage Depopulation and ageing of population	
2012	Features of biomacromolecule complexes	Scientific principles for the development of advanced test systems for the diagnosis and treatment of human hereditary diseases, effective delivery systems for targeted therapeutic genes in cells and organs were created	Gene therapy, therapeutic use of stem cells	Medicine	Depopulation and ageing of population	
		The research on the improvement of the methods of the target-oriented search of selective biologically active substances has been carried out	Selective biologically active substances	-«-	-«-	
	Molecular and cellular technologies	The scientific aspects of new strains of microorganisms and plants producers of drugs were studied	New strains producers of drugs	Medicine	Depopulation and ageing of population	
		The work on the creation of the latest biotechnologies in order to increase the productivity of agricultural plants and their resistance to the action of biotic and abiotic factors are carried out	Increase in productivity and sustainability of agricultural plants	Agriculture	Food shortage	
	Genomics	The scientific principles of the comparative genomics of plants and animals (including rare and endangered species) were developed	Saving the gene pool and finding new genes	Agriculture Medicine	Food shortage Depopulation and ageing of population	
	Biologically active substances	Research into the molecular mechanisms of action of biologically active substances, growth regulators and plant protection products was conducted	Creation of insecticides, fungicides, herbicides	Agriculture	Food shortage	
	2013	Features of biomacromolecule complexes	A highly expressive producer of recombinant scFv antibodies specific to human protein C has been obtained. Work was carried out to obtain monoclonal antibody-specific human C	Development of the immunoassay method for determining the	Medicine	Depopulation and ageing of population

Year	Sector of the programme	The most significant result	Practical utility	Branch	The global problem
		proteins	concentration of protein C in human plasma		
		The differentiation and integration of neutral stem cells transplanted in the modeling of cerebral ischemic injury in vitro and in vivo were investigated. According to the results of cerebral ischemia modeling, these cells are able to restore the functions of the damaged tissue of the hypocalumand to form synaptic terminals	Use of stem cells to restore the function of the damaged tissue of the hypocalm	-«-	-«-
		Transcriptional studies of proteinurin expression from the PKD1 and PKD2 family in malignant tumors of the stomach were conducted. It was discovered that the level of PKD2 expression in malignant tumors of the stomach correlates with the prevalence and stage of the tumor process, in particular, with the presence of metastases. A test system was developed for differential determination of the level of expression of human mRNA protein kinases using real-time CPCR	Development of a test system for the diagnosis of malignant tumors of the stomach	-«-	-«-
2013	Molecular and cellular technologies	Prototypes of test systems for the determination of the hereditary predisposition to the development of ischemic stroke and the prognosis of the effectiveness of anti-aggregate therapy in specialised health care establishments were established	Development of a prototype test system for the diagnosis of ischemic stroke	-«-	-«-
	Genomics	The use of "vector cells" as a multipurpose tool for changing the microenvironment was investigated	Use of stem cells	-«-	-«-
		Three species of trichinella were identified in wildlife of Ukraine: Trichinella britovi, Trichinella native, Trichinella spiralis.	The first DNA library in Ukraine was formed Trichinella	Agriculture Medicine	Food shortage Depopulation and ageing of population
	Biologically- active substances	The study of the molecular genetic polymorphism of varieties and lines of winter soft wheat was conducted to determine the influence of the Glu-B1a1 allele on the parameters of baking quality	The ability to quickly differentiate breeding samples of wheat	Agriculture	Food shortage
2014	Features of biomacromolecules complexes	The method of determination of sial-containing receptors on the surface of the influenza virus, herpes types 1 and 2, hepatitis C and HIV in the human and animal organism was developed.	A test system for the diagnosis and treatment of viral infections using	Medicine	Depopulation and ageing of population

Year	Sector of the programme	The most significant result	Practical utility	Branch	The global problem
			molecular forms of sialo-specific lectins as immunosorbents		
	Molecular and cellular technologies	Animal models of brain tumors have been created using cellular lines of glial and non-glial origin.	Ability to use for testing anticancer drugs in vivo to create new drugs	-«-	-«-
	Biologically active substances	The methodology of cultivating the roots of endangered and rare plants, which are used in medical practice was developed. A collection of cultures of isolated and transformed roots of different types of plants was created and analysed	The use of these plants as a potential source of compounds with biological activity	Agriculture Medicine	Food shortage Depopulation and ageing of the population
	Biotechnology	The methodology of cultivating the roots of endangered and rare plants, which are used in medical practice was developed. A collection of cultures of isolated and transformed roots of different types of plants was created and analysed	The use of these plants as a potential source of compounds with biological activity	Agriculture Medicine	Food shortage Depopulation and ageing of population
		The biotechnology of the accelerated production of new forms of wheat was developed for the first time	Wheat with a high-resistance to ophiopoil root rot and water scarcity	Agriculture	Food shortage
		An effective wheat supply system was developed and introduced into production	A power system which provides a grain production increase of 10-15%	-«-	-«-

Composed by: [23-26].

Table B.3. The most significant results of the implementation of the target complex interdisciplinary programme for scientific research "Molecular and Cell Biotechnology for the needs of Medicine, Industry and Agriculture for 2015-2019" for 2015

Year	Sector of the programme	The most significant result	Practical utility	Branch	The global problem
1	2	3	4	5	6
2015	Features of biomacromolecules complexes	A model of perinatal hypoxic-ischemic injury of the brain of animals in combination with inflammation was created	Usage of perinatal pathology of the central nervous system in further studies	Medicine	Depopulation and ageing of population
	Molecular and cellular technologies	Selection of immunophenotypical cell markers was performed	The ability to determine the initial stages of leukemization	-«-	-«-

Year	Sector of the programme	The most significant result	Practical utility	Branch	The global problem
			of bone marrow by various forms of $\beta$ -cell lymph		
		Considering the presence and nature of the expression of the different diagnostic immunodeficiency chemical markers	Allows you to identify rare cases of leukemia	-«-	-«-
	Genomics	A base of the clinical data of patients diagnosed with chronic viral hepatitis C was created. The diagnostic methods of polymorphism analysis of certain genes were developed and tested	This methods will become the basis of the pharmaco-genetic testing of this disease	-«-	-«-
	Biologically active substances	Modification of the method of determination of cytokillins in micellar biomass of basidial fungi was carried out and data on the content of these hormones in 6 types of fungi were obtained. The most productive strains were determined and the method of drying the mushroom material was introduced	A possible preparation of drugs with high biological activity	-«-	-«-
	Biotechnology	The crossing of winter wheat of the Kuyalnik strain (as a source of extra baking quality of flour) was carried out. The seeds of the second generation and the first backcross generation were obtained	Creation of selective breeding populations	Agriculture	Food shortage
		The method of stepped cell selection yielded callus lines and regenerants of soft wheat of Khutoryanka strain	Wheat varieties resistant to the simulated water scarcity	-«-	-«-
		The prospective strains of grain cereal crops for further selection with a high level of accumulation of valuable human microelements (iron, zinc, manganese, selenium) are determined	New strains of cereals with a high level of trace elements for human	-«-	-«-
		Doses of acute irradiation of medicinal plants' seeds that stimulate the accumulation of biomass and the synthesis of secondary metabolites are determined. Methods of growing these plants, as well as selection and determination of secondary metabolites in medicinal raw materials were developed	Methods of cultivating medicinal plants that cause the synthesis of secondary metabolites	-«-	-«-

Composed by: [23-26].